Towards Exascale Computing of Compressible Flows using LBM, Phase I

Completed Technology Project (2018 - 2019)

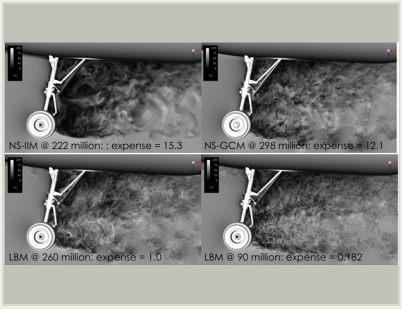
Project Introduction

As computer architecture becomes more parallel, numerical simulations must follow suit and exploit parallel algorithms effectively. An exascale-capable computational fluid dynamic method using Lattice Boltzmann Method (LBM) has been proposed to simulate compressible flow. The method is embarrassingly parallel which allows the method to fully utilize parallel architectures such as Graphics Processing Units (GPUs). The method improves upon previous methods and allows for variable fluid properties including specific heat ratio and Prandtl number. In addition, the method increases the traditional Mach number limit of LBM from 0.2 to 3.0 allowing for the method to simulate transonic and supersonic phenomena. The Phase I project will investigate the accuracy and speed of the method with respect to existing NASA solvers including NASA OVERFLOW and NASA FUN3D. The LBM solver will be written in serial and in parallel using NVIDIA's CUDA to allow for GPU use. Future work is discussed to improve upon the method and to incorporate the method into NASA solvers such as NASA LAVA and NASA Cart3D.

Anticipated Benefits

NASA applications include incorporating the method directly into NASA solvers such as NASA LAVA and NASA Cart3D. LBM is well-suited for Adaptive Mesh Refinement (AMR) Cartesian grids which both solvers utilize. Low-Mach LBM is already implemented in NASA LAVA which will allow for the proposed compressible LBM to be easily integrated. The method can be used to simulate loads and acoustics on experimental subsonic/supersonic aircraft and helicopters that NASA is interested in.

An in-house 3D solver can be developed using existing AMR frameworks to enable a commercial product. The solver can be used to simulate commercial subsonic/supersonic aircraft and helicopters. The LBM for low-speed flows is demonstrated to be one to two orders of magnitude faster than existing CFD methods. In addition, AMR grids are automatic which reduces time to solution by eliminating the time-consuming gridding process that is present in existing unstructured and block-structured approaches.



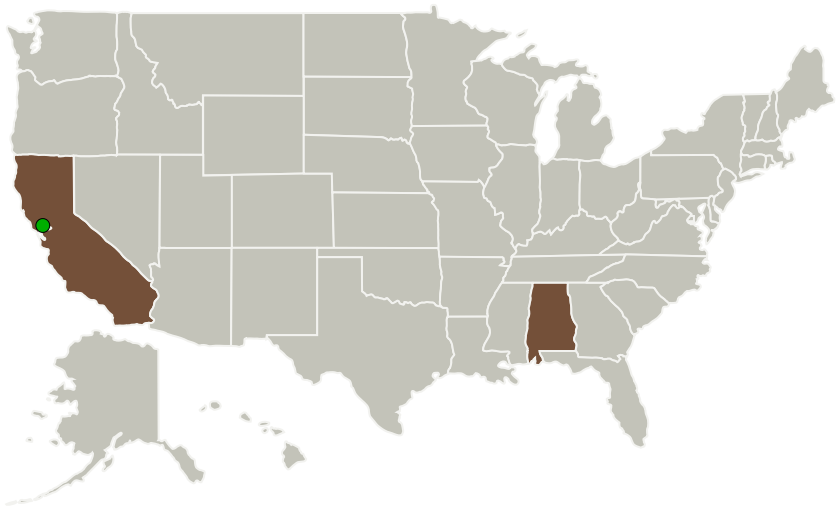
Towards Exascale Computing of Compressible Flows using LBM, Phase I

Table of Contents

Towards Exascale Computing of Compressible Flows using LBM, Phase I

Completed Technology Project (2018 - 2019)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Kord Technologies	Lead Organization	Industry	Huntsville, Alabama
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations	
Alabama	California

Project Transitions

July 2018: Project Start

February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/138707)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Kord Technologies

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

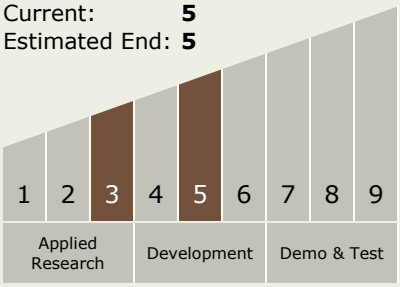
Carlos Torrez

Principal Investigator:

Bono Wasistho

Technology Maturity (TRL)

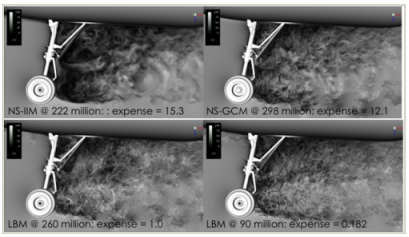
Start: **3**
Current: **5**
Estimated End: **5**



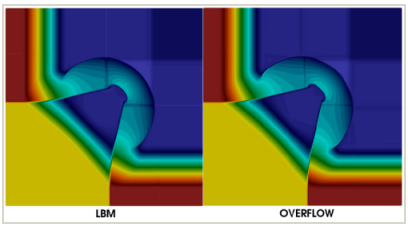
Towards Exascale Computing of Compressible Flows using LBM, Phase I

Completed Technology Project (2018 - 2019)

Images



Briefing Chart Image
Towards Exascale Computing of Compressible Flows using LBM, Phase I
(https://techport.nasa.gov/image/127231)



Final Summary Chart Image
Towards Exascale Computing of Compressible Flows using LBM, Phase I
(https://techport.nasa.gov/image/127879)

Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.3 Simulation
    - TX11.3.5 Exascale Simulation

Target Destination

Earth